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RESEARCH PAPER

Deforestation and the Environmental Kuznets Curve in Iran

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Abstract Property rights, the agricultural price index, forest area, population, income and timber price are important factors in the deforestation process. The aim of this study was to test the impact of these factors on deforestation in Iran using an environmental Kuznets curve (EKC). The autoregressive distributed lag approach was also used to estimate the deforestation function. The existence of an inverted U-shaped EKC for deforestation in Iran was confirmed. In addition, there is evidence of a relationship between deforestation and property rights, forest area, agricultural price index and terms of trade. It is concluded that improvement of secure property rights and environmental policies can improve compliance regarding forest land use and reduce the deforestation rate in Iran.

Keywords Property rights · Population ratio · Wood price index · Environmental policies

Introduction

The Global Forest Resources Assessment 2000 found that 56 countries (including Iran) are low-forest-cover countries, having less than 10 % of their area classified as forest (FAO 2003).Iran is located in southwest Asia and borders the Gulf of Oman, Persian Gulf and Caspian Sea. Its mountains have helped to shape both the political and economic history of the country for several centuries. With an area of 1.65 M km^2, Iran ranks 18th in size among the countries of the world. Less than 10 % of the country is forested. The most extensive forests are found on the mountain slopes rising from the Caspian Sea. Commercial harvesting operations are carried out in northern forests, while all other forests in Iran are non-commercial.

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These forests are on land with uneven topography and very steep slopes (Iranian Forests and Rangelands Organization 2010).

According to the FAO and Iranian Forests and Rangelands Organization reports, only 4.5 % of Iran land is covered with forest. The area of natural forest in Iran is approximately 7.3 M ha with an associated rural population of 39 % of the national population and a population density of 41.2/km^2 (FAO 2003, 2010; Iranian Forests and Rangelands Organization 2010). The annual rate of deforestation in Iran is 2.3 % in the northern part of the country and 1.1 % in other regions (Abbasi and Mohammadzadeh 2001). The lack of reliable data on natural forests constrains the monitoring of deforestation trends in Iran, but there is no question that natural forests in Iran are under serious threat. The main causes of deforestation in Iran are overgrazing, clear cutting, woodfuel use and conversion of forests to agricultural land (Amirnejad et al. 2006). Planned forest management in Iran has a 40-year history, a relatively short period in comparison to many developed countries which have, in some cases, 200 years of relevant experience (FAO 2003, 2010).

Deforestation is a major environmental problem due to its impact on greenhouse gas emissions, carbon sequestration and biodiversity (Brown and Pearce 1994; Bhattari and Hammig 2001; Nguyen-Van and Azomahou 2007). Researchers have described several factors that affect deforestation, including export prices of forestry products (Capistrano and Kiker 1995), population growth (Allan and Barnes 1985), agriculture output (Brown and Pearce 1994), fuel use, grazing, construction (Repetto 1988; Brown and Pearce 1994; Culas 2007), property rights and institutional factors (Culas 2007), exchange rates (Arcand et al. 2008) and poverty (Zwane 2007).

Recently, environmental economists have used the Kuznets Curve to explain the relation between income growth and environmental degradation. This approach implies that during the initial stage of development, environmental degradation is visible, but increasing income provides incentives to improve environmental quality. A similar hypothesis can be made about income growth and reduction in deforestation (Cropper and Griffiths 1994; Bhattari and Hammig 2001; Lopez 1994; Culas 2007). In many developing countries, increasing economic growth promotes the substitution of forests with alternative sources of energy and inputs. It is also possible that societies with higher incomes place greater emphasis on the non-market benefits of forests, such as wildlife conservation and biodiversity.

Lopez (1994) provided the theoretical basis of the environmental Kuznets curve (EKC) for deforestation. According to the inverted U-shaped EKC, at a low level of economic growth an increase in income will accelerate the rate of deforestation, but after a turning point is reached an increase in income will decrease the deforestation rate. The EKC shows an inverted U shape between gross domestic product (GDP) and natural resources degradation (Culas 2007). The theory is based on the work of Kuznets (1955) who postulated an inverse U-shaped relationship between the level of economic development and the degree of income inequality. Although several researchers have found evidence of an EKC relationship for deforestation around the world (e.g. Cropper and Griffiths 1994; Deacon 1994; Knack and Keefer 1995; Koop and Tole 1999; Nguyen-Van and Azomahou 2007; Arcand et al. 2008; Zwane 2007), only a few authors have tested the effect of institutional and property rights

on deforestation (including Bhattari and Hammig 2001; Culas 2007). Government forestry policies, trade restriction, prices and land development are all seen as factors contributing to deforestation (Hartwick and Olewiler 1998).

Barbier et al. (2010) studied more than 140 economic models relating to tropical deforestation. They found more roads, higher agricultural prices, lower wages, and off-farm unemployment generally lead to more deforestation. Buitenzorgy and Mol (2011) investigated deforestation and compared the explanatory power of democracy versus economic development. They showed democracy has greaterexplanatory power than income with respect to deforestation rates.

Although widely studied, deforestation remains a common research topic. The relationship between economic development and deforestation is still uncertain. Choumert et al. (2013) reviewing71 studies shed light on why EKC results differ. They investigated the incidence of choices made by authors on the probability of finding an EKC, concluding that the EKC story will not fade until theoretical alternatives are provided.

This study attempted to identify an EKC for deforestation in Iran. Most previous researchers have used panel data to test for presence of an EKC for groups of countries. In panel data estimates, there are omitted variables correlated with GDP, but these variables are not common to all countries (Roca et al. 2001). Thus, omitted variables may result in a biased estimate of the EKC (Stern and common 2001).

Research Method

Time series data for 1976–2006 were analyzed to provide a more clear depiction of deforestation in Iran. The agricultural price index, export-to-import price ratio (terms of trade),income, population ratio (ratio of urban to rural population), forest area, wood price index and property rights regime were used as explanatory factors. The descriptions of these factors and their expected effect on deforestation are summarized in Table 1. All data except deforestation rates were obtained from the Statistic Center of Iran.

Deforestation is defined as decrease in forest area. Forest area data were obtained from the FAO database and the Iranian Forests and Rangelands Organization. Forest land is subject to encroachment for agricultural activities, and the agricultural price index is used to represent deforestation through conversion of forest to agricultural land. The choice between forest and agricultural use of the land depends on the time preference of individuals because wood production implies a longer-term investment in forestry (Arcand et al. 2008). The wood price index shows the interest of forest harvesters in commercial and trade use of forests. The export-to-import price ratio measures the terms of trade. When a country experiences increasing terms of trade, this means the country has moved from exporting agriculture products and raw materials to exporting industrial products. In other words, it is expected that an increase in the terms of trade decreases agricultural exports and deforestation. Government macroeconomic policies, including monetary and fiscal policies, as well as domestic and international trade policies, have effects on the conservation and use of natural resource (Culas 2007).

Table 1 Description of variables and their expected relation with deforestation

Variable	Description	Unit	Expected sign
GDP	Per capita real GDP	1,000,000 Rial[a]	Positive
GDP^2	Square of per capita real GDP	1,000,000 Rial	Negative
POP	Population ratio (urban/rural ratio)	1,000,000 person	Negative
TT	Export price index	1990 = 100	Positive
WPI	Wood price index	1990 = 100	Positive
FA	Forest area	1,000 ha	Non predicted
API	Agricultural price index	1990 = 100	Positive
T	Time trend	Year	Not predicted
α	Intercept	–	Not predicted
PRD	Dummy variable for property right non clear = 1 otherwise = 0	0 or 1	Positive

[a] 12260 Iranian Rial equaled 1 US$ in April 2013

Population growth usually increases deforestation due to the use of timber for new construction. The effect of population growth on deforestation has been studied by many researchers (e.g. Allan and Barnes 1985; Cropper and Griffiths 1994; Koop and Tole 1999; Unsivuori et al. 2002; Nguyen-Van and Azomahou 2007). Some researchers have found a positive relationship between population growth and deforestation (e.g. Allan and Barnes 1985; Cropper and Griffiths 1994; Unsivuori et al. 2002), while others have concluded the relationship is negative or no relationship exists (including Koop and Tole 1999 and Nguyen-Van and Azomahou 2007). Property rights are also an important variable for efficient forest harvesting and reforestation. Clear property rights and regulations will decrease deforestation.

The econometric model that was used to test EKC for deforestation in Iran is as follow:

$$DEF_t = \alpha + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 FA_t + \beta_4 POP_t + \beta_5 API_t + \beta_6 TT_t + \beta_6 PRD_t + \beta_7 T + \varepsilon_t$$

Where DEF_t is deforestation in year t, T is time, ε is an error term, and the other variables are as defined in Table 1. In order to choose an estimation strategy for the above model the stationary characteristics of the data were tested. An empirical study based on time series data assumes that the underlying time series is stationary (Greene 2000).

Results

The findings of the stationary test for variables are reported in Table 2. Based on the fact that variables can have a differing order of stationary, an autoregressive distributed lag (ARDL) approach is used to estimate the deforestation model. Here the regression analysis is designed to explain the values of the dependent variable based on both the current values and the lagged (past period) values of explanatory

variables. The main advantage of the ARDL estimation procedure is that it can be applied irrespective of whether the regressors are I(0) or I(1). The ARDL procedure involves two stages. In the first stage, the existence of a long-term relationship between the variables is tested with an F-statistic. In the second stage the coefficients of the long-term and short-term relationship are estimated and inferences are made about their coefficient values (following Greene 2000).

The results from estimating the ARDL model and long-term estimates are presented in Tables 3, 4. The results reveal the existence of an inverted U-shaped EKC for deforestation in Iran in the long run. The coefficients of both GDP and GDP squared are statistically significant, and have a positive and a negative sign, respectively (Table 4). This is consistent with the hypothesis that an increase in GDP per capita stimulates demand for agricultural products and that drives deforestation. However, at higher levels of GDP per capita, people substitute other materials for forest products, and they prefer to protect forest land and decrease deforestation. Based on the estimated relationship the turning point is a per capita income of 301.04 million Rials (equal to $US 24555), which is located within the observed per capita GDP range.

Forest area is added to the model to indicate forest scarcity. The forest area coefficient is found to be significant, as anticipated. The agricultural commodity price index (API) is used as the variable to explain the effect of the agricultural activities on deforestation. The agricultural sector plays a major role in the economics of many developing countries. The export–import price ratio (terms of trade) coefficient is significant as expected in Table 1. Higher terms of trade increase a country's trade advantage in the world market.

The wood price index coefficient is positive, but not significant due to the small share of domestic wood production in total wood consumption. The time trend coefficient is positive and significant. This suggests that the effect of time-dependent variables including openness to technological change works in favour of protecting forest area.

Property rights to forests can have major impacts on the use of the land. In some years (such as during the Iranian revolution in 1979), forest property rights have not

Table 2 Stationarity test result for variables used in the model

Variable	Stationarity	ADF[a]	Number of time periods of the lag (year)
GDP	I(1)[b]	−2.83	0
DEF	I(0)	−1.53	1
POP	I(0)	−12.98	1
TT	I(1)	−2.94	1
WPI	I(0)	−3.47	0
FA	I(0)	−4.59	0
API	I(1)	−4.4	0

[a] Augmented Dickey-Fuller Unit Root Test

[b] I(1) and I(0) are stationary with first difference and level (without difference) for the explanatory variables

Table 3 ARDL(1,0,1,1,1,0,0,0) selected based on Akaike Information Criterion

Variable	Coefficient	t value
DEF_{-1}	−0.32	−1.64
GDP	58,919.5[a]	1.94
GDP^2	−97.85[a]	−1.8
POP	−11,983.2	0.126
TT	−456734[c]	−3.13
WPI	4,800	0.59
FA	0.115[a]	2.33
FA_{-1}	0.133[b]	2.53
API	36,503[c]	3.12
α	−8,815,261[a]	−1.75
T	−245,983.2[b]	−2.78
PRD	1,212,562[b]	2.22

$R^2 = 0.86^a$ $F = 9.04^b$
D.W = 2.06

a, b and c indicate statistical significance at the 10, 5 and 1 % level, respectively

Table 4 Estimates of the long-term coefficient based on selected ARDL model

Variable	Coefficient	t-value
GDP	44,794.4[a]	1.99
GDP^2	−74.4[a]	−1.85
POP	−9,110.4	−0.126
TT	−347,238.4[c]	−3.52
WPI	3,649.3	0.61
FA	0.188[b]	2.64
API	27,752[c]	2.97
α	−6,701,925[a]	−1.77
T	−187,012[b]	−2.85
PRD	921,867[b]	2.25

a, b and c indicate statistical significance at the 10, 5 and 1 % level, respectively

been clear in Iran. Hence it is expected that deforestation will have increased during the study period.

PRD is a dummy variable used to represent property rights. The PRD value is set at 1 for the 1979 and 1991–98, these being times when property rights and forest management policy were changing and unstable. During these years, forest regulations changed dramatically and management of Iranian forestry was transferred between government organizations. The coefficient of property rights in Table 4 is positive and significant as expected.

The coefficient for the urban-to-rural population ratio is negative as expected, but this coefficient is not significant. It seems that rural populations in Iran are more dependent than urban residents on agriculture and forest production, but due to the non-significant coefficient it is difficult to draw a conclusion.

The results of the error correction model are shown in Table 5. The error correction coefficient, estimated at −1.3, is statistically highly significant. The coefficient has the correct sign and suggests a fast (9 months) convergence to

Table 5 Error correction model for selected ARDL model

Variable	Coefficient	t value
GDP	58,919.5[a]	1.94
GDP^2	−97.85[a]	−1.81
POP	−11,983.2	−0.126
TT	−456,734[c]	−3.13
WPI	4,800	59,237
FA	0.115[a]	2.33
API	36,503[c]	3.12
α	−8,815,261[a]	−1.75
T	−245,983[b]	−2.78
PRD	1,212,562[b]	2.22
Eco(−1)	−1.3[c]	−6.82

[a], [b] and [c] indicate statistical significance at the 10, 5 and 1 % level, respectively

equilibrium.[1] The larger the error correction coefficient (in absolute value) the faster is the economy's return to its equilibrium after a period of shock.

Discussion

The analysis confirms the existence of an inverted U-shaped EKC for deforestation. That is, deforestation increases faster than income at early stages of development and slows relative to GDP growth at higher income levels. This result is similar to the finding of Godoy et al. (1997). On the other hand the analysis indicates that the deforestation rate is reduced at higher income levels, which is consistent with the FAO 2003 and 2010 annual reports about Iran forest.

During the last three decades, considerable change has taken place in forest management due to the reinforcement of an ecosystem management strategy. Even-aged stands have been changed into uneven-aged stands, clear cutting in restoration areas in the West has been stopped, spot cutting in limited areas has attracted attention of government and non-governmental organizations in favour of forest conservation, and harvest rates have diminished. Despite concerns about population pressure accelerating deforestation, no significant relationship could be detected between the population factor (urban/rural ratio) and deforestation. This may be due to increased immigration from rural areas to cities during recent years. Rural populations can have a large impact on deforestation; if population growth is accompanied by migration from rural areas to the cities, it may decrease deforestation. According to Iranian demographic data, the rural population has decreased from 53 to 32 % of Iran's total population from 1976 to 2006 (Statistical Center of Iran 2008). The impact of the population movement on the environment can be modified by economic growth (Cropper and Griffiths 1994). It is also noted

[1] The Error Correction Model shows speed of convergence to equilibrium after a shock (policy change). The model suggests fast response (12 months/1.3 = 9 months).

that populations of countries may reduce the rate of deforestation through innovation and technological progress (Culas 2007).

Positive and significant values for the export to import price (terms of trade) might be due to a shift from exports of primarily agricultural and forest products to a greater reliance on industrial and value-added products. The agricultural price index has a statistically significant effect on deforestation in Iran. Maestad (2001) concluded that the agricultural products price change can increase or decrease the rate of deforestation. Increasing agricultural product prices might expand agricultural landuse and increase deforestation. The expansion of agricultural production onto forest land is considered an important strategy for increasing agricultural production and income (Culas 2007). Angelesen and Kaimowitz (1999) also concluded that higher agricultural and timber prices, resulting from trade liberalization, would increase the rate of deforestation. The statistically significant result for forest area might be due to increased management of forest resources in Iran. Decreasing forest area may draw increased attention to the need to protect limited forest resources and slow the deforestation process.

The property right coefficient indicates that instability in property rights for forests have had a major impact on deforestation in Iran. During the transitory privatization period (1991–98) there was insecurity regarding forest management in Iran. The value and term of timber concessions have been important policy issues. Insecure timber concessions and unstable ownership rights to forest land have contributed to deforestation in many parts of the world (Hartwick and Olewiler 1998). Some authors believe that it might be effective to focus efforts on controlling deforestation by improving environmental policies and institutional organization (Culas 2007). Bhattari and Hammig (2001) concluded that political institutions can reduce the rate of deforestation by regulatory measures (causing a downward shift in the EKC).

Conclusions

The analysis confirms the existence of an inverted U-shaped EKC for deforestation in Iran. The agricultural price index has a significant effect on deforestation. In addition, the property right coefficient indicates that property rights for forests have had a major impact on deforestation in Iran.

Quantitative models of deforestation rarely test the effect of property rights on deforestation. Data scarcity is one of the main constraints for such studies. The study presented here focuses on deforestation in Iran using time series data. Panel data or cross-sectional data might examine deforestation factors in groups of countries; time series analysis applied to data of specific countries can provide more clear findings.

Considering possible future developments of deforestation analysis, the first action could be to improve the current dataset extending the time series in order to test more explanatory variables, including income distribution and corruption index. Secondly, field observation will be highly useful and a considerable improvement for the study of deforestation.

Continued deforestation will eventually exhaust the forest resources. Therefore, it is crucial that policy-makers implement polices to increase the sustainability of forestry by broadening property rights and facilitating a higher per capita income.

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